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(54) [Title of the Invention] SHEET FRIT, METHOD OF HERMETIC SEALING OF VACUUM VESSEL, AND METHOD FOR MANUFACTURING IMAGE DISPLAY DEVICE

(57) [Abstract]

[Object] To provide a method for reliable hermetic sealing of a vacuum vessel with good productivity for manufacturing a large size vacuum vessel, particularly a flat image display device.

[Construction] Sheet frits prepared by calcinating small pieces of frit grass sheets are used as a hermetic sealing material. The sheet frit 101 to 106 comprises an engaging part, or steps 101a and 104a, grooves 102a, and inclined faces 105a and 106a. A plurality of sheet frits are disposed on hermetic sealing parts so as to engage the engaging parts with each other, and the vacuum vessel is

hermetically sealed by heating the sheet frits. When tablets of the sheet frits having no engaging parts are used, the sheet frits are disposed on the sealing part so that both ends of the sheet frits are displaced with each other.

[Claims]

[Claim 1] A sheet frit comprising a glass frit molded into a sheet for use in hermetic sealing of a hermetic part, the sheet frit having a pair of parallel planes to be in contact with a sealing object and an engaging part provided at portions except the parallel planes, and the thickness of the frit glass at the engaging part being different from the thickness at the portion of the parallel planes.

[Claim 2] The sheet frit according to Claim 1, wherein the engaging part is formed as a step connected to the parallel plane.

[Claim 3] The sheet frit according to Claim 1, wherein the engaging part is formed as an inclined face connected to the parallel plane.

[Claim 4] A method for hermetically sealing a vacuum vessel for forming a vacuum vessel by hermetically sealing a plurality of sealing objects,

wherein a plurality of the sheet frits according to any one of Claims 1 to 3 are used, the sheet frits are disposed so that the engaging parts are engaged with each other, and the sealing object is hermetically sealed with the sheet frits by heating.

[Claim 5] A method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face

plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source,

wherein a plurality of the sheet frits according to any one of Claims 1 to 3 are used, the sheet frits are disposed at a sealing part of the rear plate or face plate so that the engaging parts are engaged with each other, and the rear plate and face pale are hermetically sealed with the sheet frits by heating.

[Claim 6] A method for manufacturing an image display device for hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source,

wherein a plurality of the sheet frits according to any one of Claims 1 to 3 are used, the sheet frits are disposed so that the engaging parts are engaged with each other as a disposed shape corresponding to the shape of the sealing part of the rear plate or face plate, the plural sheet frits are integrated by heating only the engaging part, the integrated sheet frits are disposed at the sealing part of the rear plate or face plate, and the rear plate and face plate are hermetically sealed with the integrated sheet frits.

[Claim 7] A hermetic sealing method for forming a vacuum vessel by hermetically sealing a plurality of sealing objects using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprising:

a first step for disposing the sheet frits so that the sheet frits are formed as at least two layers, and so that the sheet frits are continuous on each layer; and

a second step for hermetically sealing the sealing object with the sheet frits by heating,

wherein the position of an end of the sheet frit on at least one layer of the layers is displaced from the position of the end of the sheet frit on another layer.

[Claim 8] A method for forming a vacuum vessel by hermetically sealing a plurality of sealing objects using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprising:

a first step for disposing the sheet frits on a sealing portion at the circumference so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and

a second step for hermetically sealing the sealing objects with the sheet frits by heating,

wherein the position of the end of the sheet frit in at least one line of the lines is displaced from the position

of the end of the sheet frit in another line.

[Claim 9] A method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprising:

a first step for disposing the sheet frits on a sealing portion so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and

a second step for hermetically sealing the sealing objects with the sheet frits by heating,

wherein the position of the end of the sheet frit in at least one line of the lines is displaced from the position of the end of the sheet frit in another line.

[Claim 10] A method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprising:

a first step for disposing the sheet frits on a sealing portion at the circumference so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and

a second step for hermetically sealing the sealing objects with the sheet frits by heating,

wherein the position of the end of the sheet frit in at least one line of the lines is displaced from the position of the end of the sheet frit in another line.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The invention relates to a method for hermetically sealing a vacuum vessel, particularly to method for manufacturing an image display device for image display using an electron beam and a method for hermetically sealing in the manufacturing process. The invention also relates to a sheet frit comprising a frit glass used for hermetic sealing.

[0002]

[Description of the Related Arts] Cathode-ray tube (CRT) displays have been practically used as image display devices having excellent characteristics such a wide angle of vision, readiness of color display and high luminance. However, needs for image display devices capable of displaying fine

images and having a flat large size screen have been rapidly increased in accordance with high information processing performance of computers and high image quality of television broadcasting.

[0003] Accordingly, some image display devices have been proposed by taking advantage of the merit of usual CRT displays while being a flat electron beam acceleration type. For example, Japanese Patent Application laid-Open No. 56-28445 has disclosed an image display device having a construction in which many electron sources are disposed in a plane, electron beams are emitted from the electron sources, and the electron beams are controlled and accelerated with a group of control electrodes having many holes corresponding to fluorescent pixels to irradiate the accelerated electron beams on a flat fluorescent screen in order to emit a light from desired fluorescent pixels.

[0004] Two kinds of electron sources of a thermoelectron source and cold cathode electron source are known in the art. Although the thermoelectron source has been used for a long period of time, it is not suitable for the uses in which many electron sources are disposed in a plane considering reliability, service life, heat generation and consumption of electricity. Accordingly, the cold cathode type is notices as the electron source for a flat image display device. The cold cathode electron source include a field

emission type (abbreviated as a FE hereinafter), a metal/insulation layer/metal type (abbreviated as a MIM type hereinafter), and a surface conduction type (abbreviated as SCE type hereinafter). An example of the FE type known in the art is that described in "Field Emission" by W. P. Dyke and W. W. Dolan, Advance in Electron Physics, 8, 89 (1956). Examples of the MIM type known in the art is that described in "The Tunnel Effect Amplifier" by C. A. Mead, J. Appl. Phys., 32, 646 (1961), and in "Physical Properties of Thin-Film Field Emission Cathode with Molybdenum Cone" by C.A. Spindt, J. Appl. Phys., 47, 5284 (1976).

[0005] On the other hand, an example of the SCE type is a cold cathode element reported by M. I. Elinson [Radio Eng. Electron Phys., 10, 1290-1296 (1965)]. The CSE electron emission element takes advantage of a phenomenon in which electrons are emitted by flowing an electric current on a small area thin film plane formed on a substrate.

[0006] The inside of the display device containing a flight space of the electron beam should be kept vacuum for long years in the flat image display device using the electron beam. Accordingly, the flat image display device has a construction in which a supporting frame is inserted between a face plate including a fluorescent substance and a rear plate on which the electron emission elements are arranged as a matrix, an outer enclosure is formed with these members,

and the space in the enclosure is evacuated to vacuum. The sealing face between the face plate and supporting frame, and the sealing face between the rear plate and supporting frame are usually hermetically sealed with a glass material. While the structure may use no supporting frame, the face plate and rear plate are also hermetically sealed with the glass material in this case. Practically, a low melting point glass frit that is stable for a long period of time is used. The low melting point as used herein means that the glass frit is softened at a lower temperature than the softening point of a glass plate constituting the rear plate and face plate, because the rear plate and/or face plate is made of a glass. After hermetically sealing the enclosure as a main unit of the image display device, the enclosure is evacuated to hermetically seal a getter flash and evacuation tube to complete a vacuum vessel.

[0007] The enclosure is usually hermetically sealed by fusing the glass frit. The glass frit used in the hermetic sealing process comprises a $PbO \cdot B_2O_3$ low melting point glass powder mixed with a special ceramic. The enclosure is hermetically sealed by the steps comprising applying by printing a paste prepared by adding an acrylic resin having a relatively low degree of polymerization and a solvent to the glass frit on at least one sealing face, calcinating at a required temperature (usually a temperature lower than the

sealing temperature) for removing the resin in the coating film by decomposition, and finally baking by abutting both members interposing the sealing face to put the glass frit into a semi-fusion state. When a relatively small enclosure is hermetically sealed, for example sealing of small display devices such as a vacuum bulb or fluorescent display tube, the enclosure is hermetically sealed by the steps comprising preparing a mixture of a glass frit powder, an acrylic resin having a relatively low degree of polymerization and a solvent, forming a preform sheet by forming the frit glass into a sheet by calcination after forming a shape resembling to the sealing part of the enclosure, and baking the preform sheet after disposing it at the sealing part of the enclosure.

[0008]

[Problems to be Solved by the Invention] However, the following problems arise when attempting the usual sealing method to apply for manufacturing the flat image display device having a larger size.

[0009] (1) Calcination is necessary for removing the acrylic acid in the paste of the frit in the hermetic sealing method by applying the paste of the frit on the sealing face. The sealing work takes much labor since at least two heat cycles should be applied to a sealing object such as the enclosure. In addition, a different baking

furnace should be prepared or the baking temperature should be changed for every heat cycles to cause a high cost since manufacturing facilities and manufacturing spaces are required for the process.

[0010] (2) Although only one cycle of the heat cycle is applied to the sealing object when a preform sheet frit is used, the size of the sealing part becomes large when attempting to seal a large size sealing object. The sheet frit corresponding to such large sealing objet is difficult to manufacture. Particularly, such manufacturing is not easy since contraction and warp caused by calcination is difficult to control. Moreover, handling of a thin sheet frit is difficult, and the sheet may be cracked or broken during handling even if manufacturing thereof be possible.

[0011] The object of the invention performed by considering these and other problems is to provide a hermetic sealing method for reliably sealing with high productivity in manufacturing a large size vacuum vessel, particularly a flat image display device, and to provide a sheet frit suitable for applying such hermetic sealing method.

[0012]

[Means for Solving the Problems] The invention provides a sheet frit comprising a glass frit molded into a sheet for use in hermetic sealing of a hermetic part. The sheet frit has a pair of parallel planes to be in contact with a

sealing object and an engaging part provided at portions except the parallel planes, and the thickness of the frit glass at the engaging part is different from the thickness at the portion of the parallel planes. While the engaging part may have an arbitrary shape, it may be formed (1) as a step connected to the parallel planes, or (2) as an inclined face connected to the parallel planes.

[0013] In a first method for hermetically sealing a vacuum vessel for forming a vacuum vessel by hermetically sealing a plurality of sealing objects, a plurality of the sheet frits according to the invention are used. The sheet frits are disposed so that the engaging parts are engaged with each other, and the sealing object is hermetically sealed with the sheet frits by heating.

[0014] In a second method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source, a plurality of the sheet frits according to the invention are used. The sheet frits are disposed at a sealing part of the rear plate or face plate so that the engaging parts are engaged with each other, and the rear plate and face pale are hermetically sealed with the sheet frits by heating.

[0015] In a second method for manufacturing an image display device for hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source, a plurality of the sheet frits according the invention are used. The sheet frits are disposed so that the engaging parts are engaged with each other as a disposed shape corresponding to the shape of the sealing part of the rear plate or face plate, and the plural sheet frits are integrated by heating only the engaging part. The integrated sheet frits are disposed at the sealing part of the rear plate or face plate, and the rear plate and face plate are hermetically sealed with the integrated sheet frits.

[0016] In a second hermetic sealing method for forming a vacuum vessel by hermetically sealing a plurality of sealing objects using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprises: a first step for disposing the sheet frits so that the sheet frits are formed as at least two layers, and so that the sheet frits are continuous on each layer; and a second step for hermetically sealing the sealing object with the sheet frits by heating. The position of an end of the sheet frit on at least one layer of the layers is displaced

from the position of the end of the sheet frit on another layer.

[0017] In a third method for forming a vacuum vessel by hermetically sealing a plurality of sealing objects using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprises: a first step for disposing the sheet frits on a sealing portion at the circumference so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and a second step for hermetically sealing the sealing objects with the sheet frits by heating. The position of the end of the sheet frit in at least one line of the lines is displaced from the position of the end of the sheet frit in another line.

[0018] In a third method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprises: a first step for disposing the sheet frits on a sealing portion so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and a second step for hermetically sealing the sealing

objects with the sheet frits by heating. The position of the end of the sheet frit in at least one line of the lines is displaced from the position of the end of the sheet frit in another line.

[0019] In a fourth method for manufacturing an image display device by hermetically sealing a rear plate having a plurality of electron sources disposed on a plane and a face plate having a fluorescent part emitting a light by irradiation of an electron beam emitted from the electron source using a plurality of sheet frits comprising a frit glass formed into small pieces of sheet, the method comprises: a first step for disposing the sheet frits on a sealing portion at the circumference so that the frits are arranged in at east two lines and so that the frits are continuous in each line, and a second step for hermetically sealing the sealing objects with the sheet frits by heating. The position of the end of the sheet frit in at least one line of the lines is displaced from the position of the end of the sheet frit in another line.

[0020]

[Operation] A frit glass powder used for a hermetic sealing material of a vacuum vessel and hermetic sealing part is formed into a sheet in the sheet frit of the invention. The engaging part of the sheet frit is formed into a shape capable of engaging a engaging part of another sheet frit.

While a pair of parallel faces to be in contact with a sealing object are formed in the sheet frit of the invention for hermetically sealing the sealing objets with each other, the engaging part is formed, for example, as steps or inclined faces for being connected to the parallel faces. When the engaging part is a step (referred to as "sheet frit with steps" hereinafter), the thickness of this step part is smaller than the thickness between the pair of the parallel faces.

[0021] In hermetic sealing using such sheet frit with steps, a plurality of the sheet frits with steps are prepared, the sheet frits with steps are aligned on the sealing part so that the step portions (the portion having a smaller thickness) are overlapped with each other, and the sealing objects are hermetically sealed by heating and baking. When the step is provided at both ends of the sheet frit, the sheet frit can be continuously aligned at the sealing part of the enclosure by overlapping the steps with each other.

[0022] Since the sheet frits with steps are used by overlapping the steps at the engaging part, the thickness of the steps are reduced to 1/2 or less of the thickness of other portions, or the overlapped sheet frits are arranged with the surface and back face thereof in alternately reversed relation with each other. This method permits the sheet frits form being cracked by the load after sealing

when the sheet frits and one of the enclosures are overlapped with each other.

[0023] Otherwise, a plurality of sheet frits with steps are overlapped corresponding to the shape of the sealing part, and the overlapped step portions are fused by heating. This method permits sheet frits integrated into the shape of the sealing part to be obtained. A laser beam may be irradiated at the overlapping part for heating the sheet frits. The frit may be heated for integration after disposing the sheet frits with steps on the sealing part, or may be heated at a position different from the fusing part. When the sheet frits are heated at the position different from the sealing part, the enclosure is hermetically sealed by disposing the integrated sheet frit after heating on the sealing part. Both methods are identical in that the sheet frits are formed into an integrated continuous sheet frit.

[0024] While the sheet frit having steps at the engaging part has been described as an example, the descriptions above are valid when the engaging part has other shapes, for example an inclined face. Furthermore, the sheet frit of the invention include a tablet of the sheet frit having a uniform thickness, wherein cut portions in the plane direction or protrusions are provided at both ends of the sheet frit.

[0025] The sheet frit of the invention can be produced by

molding a paste, which is prepared by mixing a frit glass with a binder such as an acrylic acid and a solvent, into a given shape followed by calcination. Since the shape of the sheet frit as a unit of calcination is sufficiently smaller than the size of the sealing part, the influence of contraction and warp by calcination may be neglected. The sheet frit itself can be universally used irrespective of the shape of the sealing part, and the size of a baking furnace necessary for calcination (or production of the sheet frit) may be substantially small. Accordingly, a large size vacuum vessel may be readily and reliably sealed with a low production cost.

[0026] Hermetic sealing method using the sheet frit can be applied for any vessels requiring to be evacuated such as an electronic bulb. The method may be also applied for the flat image display device having a structure for emitting a light from a fluorescent substance by accelerating electrons, or for the flat image display device having electron sources and a fluorescent substance disposed therein for emitting electrons in the space. The electron source available include SCE and FE cold cathode electron sources, and a wire thermoelectron source.

[0027] In the second and third methods for hermetically sealing the vacuum vessel, and in the third and fourth methods for manufacturing the image display device, a

plurality of sheet frits having not always provided with the engaging part are used by forming into pieces of sheet, and the sheet frits are arranged as duplicated sheets on the sealing part. The shape of the sheet frit in this case is typically a tablet. For forming the sheet frit, a paste of a frit glass powder mixed with a binder such as an acrylic resin and a solvent is formed into a give shape, and the binder is removed by calcination. This sheet frit is suitable for mass production.

[0028] The method for heretical sealing comprises: (1) the sheet frits are disposed on the sealing part in at least two layers so that the sheet frits are continuous in each layer, and so that the positions of both ends of the sheet frits in at least one layer of the layers are displaced from the positions of both ends of the sheet frits on another layer; or (2) the sheet frits are disposed on the sealing part in at least two lines so that the sheet frits are continuous in each line, and so that the positions of both ends of the sheet frits in at least one line of the lines are displaced from the positions of both ends of the sheet frits on another line. The sheet frits are heated thereafter to hermetically seal the sealing part with the sheet frit.

[0029] The sheet frits are aligned in at least two layers or two lines with a displacement with each other, in order to prevent the gaps between the sheet frits from foaming

leak passageways by not being completely blocked by hermetic sealing. This method is typically featured in the arrangement itself of the tablets of the sheet frits, and the order of arrangement of the sheet frits is arbitrary. There are no upper limits of the number of layers for laminating the sheet frits, or the number of lines for aligning the sheet frits on the circumference. All the ends of each layer or each line are not required to be displaced with each other in the method for disposing the sheet frits with a displacement of the ends between the layers or lines. Instead, the ends of the sheet frits on one layer or one line may be displaced from the ends of the sheet frits on another layer or line. Otherwise, a method for forming more than two layers or more than two lines my be used together, which may be employed for enhancing the effect of the invention.

[0030] In the second and third methods for sealing the vacuum vessel of the invention, and in the third and fourth method for manufacturing the image display device of the invention, a large size vacuum vessel and a large screen flat image display device may be readily manufactured without providing special facilities for calcination, since small pieces of the sheet frits are disposed in duplicate on the sealing part. Examples of the flat imaging device capable of applying the invention include those having a

structure for emitting a light from a fluorescent substance by accelerating electrons, or those comprising at least electron sources and a fluorescent substance disposed therein required to be evacuated in order to emit electrons in the space. The electron source in this case include SCE and FE cold cathode electron sources and wire thermoelectron sources.

[0031]

[Embodiments] The embodiments of the invention will be described hereinafter with reference to the drawings.

[0032] <Example 1> Figs. 1(a) to 1(f) are perspective views of the examples of the sheet frits of the invention, wherein those shown in Figs. 1(a) to 1(d) have steps as engaging parts, while those shown in Figs. 1(e) and 1(f) have inclined faces as the engaging parts.

[0033] The sheet frit 101 shown in Fig. 1(a) is a tablet, and the steps 101a are provided at the minor edges thereof. The sheet frit 101 has thin portions by being shaved from one principal face side at both ends in the longitudinal direction. The length L_1 of each step 101a in the longitudinal direction of the sheet frit 101 is approximately equal to the width W_1 of the sheet frit 101. The thickness at the step 101a is one half of the thickness of the other portion of the sheet frit.

[0034] An example of the method for manufacturing the sheet

frit provided with the steps will be described below. a paste of the frit was prepared by adding an acrylic resin and a solvent in a commercially available low melting point glass frit mainly comprising lead. The viscosity of the frit was adjusted to be approximately equal to a clay considering the manufacturing steps thereafter. Then, the frit is expanded as a sheet, and the sheet of the frit is leveled with a stepped roller to form the steps. The sheet is cut into tablets, and the acrylic component is dissipate by decomposition by calcinating in an oven to obtain a sheet frit having the steps. The paste of the flit may be molded in a mold to form the steps by calcinating thereafter.

[0035] In another method, the low melting point glass frit is formed into a paste of the frit by adding the acrylic resin and solvent, the steps are formed by partial grinding with a cutter after calcination, and the sheet frit with steps is manufactured by cutting the sheet into tablets. However, the yield of this method was poor since the solidified frit by calcination is liable to be broken or cracked by cutting.

[0036] The sheet frit 102 shown in Fig. 1(b) is provided with linear grooves 102a on one principal face to be close to both ends in the longitudinal direction of the tablet of the sheet frit. The groove 102a corresponds to the step that can be engaged with the step provided at the ends of

another sheet frit, and is provided so as to connect the principal edge of the sheet frit 102. The sheet frit 103 shown in Fig. 1(c) is slender and has a L-shape in the cross section. The sheet frits are used by combining the L-shaped portions with each other. While the sheet frit 104 shown in Fig. 1(d) is similar to the sheet frit 101 shown in Fig. 1(a), the shape of the former is different from the latter in that the shape is an arc in place of a tablet. The steps 104a are provided at both ends of the arc. The sheet frit 104 is suitable for sealing a circular object. The sheet frit 104 is used for forming a circle by combining an even number of the sheet frits at the sealing part.

[0037] The sheet frit 105 shown in Fig. 1(e) has inclined faces 105a at both ends in the longitudinal direction. This means that the sheet frit 105 has a trapezoidal cross section in the longitudinal direction. The sheet frit 106 shown in Fig. 1(f) has an inclined part 106a only at one end in the longitudinal direction. The inclined parts are made to contact with each other when the sheet frit 105 or 106 is disposed at the sealing part.

[0038] <Example 2> Figs. 2 and 3 shows the hermetic sealing method using each sheet frit in Example 1. The method for manufacturing the image display device having SCE electron sources will be described in this example.

[0039] Fig. 2 shows an example for forming the image

display device using four sheet frits 101 shown in Fig. 1(a). The image display device comprises a rear plate 3 on which a plurality of electron sources are disposed, a face plate 4 provided with a fluorescent substance (not shown), and an approximately rectangular shaped supporting frame 5 having penetrating evacuation pipes (not shown). The spaces between the rear plate 3 and supporting frame 5, and the spaces between the face late 4 and supporting frame 5 are hermetically sealed with bond portions 6, respectively, using the sheet frit. The space surrounded by the rear plate 3, face plate 4 and supporting frame 5 is evacuated to vacuum through the evacuation pipe.

[0040] The actual sealing method will be described below. two pieces each of the sheet frits 101 corresponding to the major and minor edges, respectively, of the supporting frame 5 are prepared, and these four pieces of the sheet frits 101 are disposed on the corresponding edge of the supporting frame 5 so that the steps 101a engage with each other. The face plate 4 is placed on these sheet frits, and they are baked by applying a given load to complete hermetic sealing between the supporting frame 5 and face plate 4. The rear plate 3 and sealing part 6 of the supporting frame 5 are also hermetically sealed by the same method. Actually, both sealing parts 6 may be simultaneously completed.

[0041] No leak was observed by evacuating the inside of the

image display device hermetically sealed as described above. This means that hermetic sealing of a large size device may be possible with no possibility of leak by hermetically sealing by disposing the plural sheet frits having steps at the sealing part.

[0042] Fig. 3 shows an example in which hermetic sealing was performed by the same method as shown in Fig. 2 using two pieces of the sheet frits 101 of the type shown in Fig. 1(a), and two pieces of the sheet frits 102 shown in Fig. 1(b). The steps 101a of the sheet frit 101 of the type shown in Fig. 1(a) is engaged with the grooves 102a of the sheet frit 102 of the type shown in Fig. 1(b). No leak was observed when the inside of the image display device hermetically sealed as described above was evacuated to vacuum.

[0043] <Example 3> While one edge of the sealing part having an approximately rectangular shape was to correspond to one piece of the sheet frit in Example 2, hermetic sealing of larger size sealing part may be possible by taking advantage of more larger number of sheet frits. An example of the hermetic sealing process for manufacturing the image display device as shown in Example 2 will be described in this example. Fig. 4(a) is a partially broken plane view of the image display device in this example, and Fig. 4(b) shows the hermetic sealing steps thereof.

[0044] The sheet frit 101 shown in Fig. 1(a) was used in this example. The plural number of sheet frits 101 were arranged on each edge of the supporting frame 5 so that the surface and back face of the sheet are alternately reversed with each other. In Figs. 4(a) and 4(b), whether the sheet frit 101 is placed with the surface (the principal surface on which the steps 101a are provides) upward, or the sheet frit 101 is placed with the back face (the principal surface on which no steps are provides) upward is distinguished by the direction of hatching relative to the sheet frit 101. The sheet frits 101 are continuously disposed in the longitudinal direction with their steps 101a overlapped except four corners of the supporting frame 5, and the steps 101a are overlapped at the four corners so that the corners are perpendicular with each other in the longitudinal direction. The face plate 4 is placed on these sheet frits, and the face plate 4 and the supporting frame 5 are hermetically sealed by baking while applying a given load from above.

[0045] No leak was observed when the inside of the image display device hermetically sealed as described above was evacuated to vacuum. This means that no leak occurs by continuously disposing many sheet frits having the engaging part, and shows that hermetic sealing of the large size sealing part represented by a large size image display

device is possible.

[0046] <Example 4> The plural number of sheet frits may be integrated by heating only the engaging part of the sheet frit before baking for hermetic sealing, when the plural number of sheet frits having the engaging part are used. The hermetic sealing step in the manufacturing process of the image display device as in Example 2 will be described in this example. Fig. 5 describes the hermetic sealing step in this example.

[0047] Four pieces of the sheet frits 101 having the steps 101a were disposed on the supporting frame 5 so that the steps 101a are overlapped with each other as in Example 2. A laser beam 20 was irradiated at the overlap portions of the steps 101a thereafter as shown in Fig. 5. Since the sheet frit 101 is colored by containing, for example, lead oxide (PbO), it is heated by the laser beam 20, and the sheet frits 101 are integrated by partial fusion of the steps 101a with each other. The face plate 4 was placed on the integrated sheet frits, and the face plate and the sheet frit was hermetically sealed by baking while applying a given load from upward.

[0048] Since the sheet frits were integrated by fusing in advance in this example, the sheet frits are hardly collapsed by sealing by baking to enhance the hermetic sealing work.

[0049] <Example 5> While the sheet frit disposed on the sealing part was partially heated in Example 4, the sheet frit was integrated by partially heating at a place other than the sealing part in this example. The sheet frit was placed at a different place before aligning the sheet frit on the supporting frame, and the sheet frit with the engaging parts was piled to partially fuse the overlapping portion with a laser beam. The integrate sheet frit was placed on the supporting frame thereafter, and the face plate was further placed thereon. The supporting frame and the face plate were hermetically sealed by baking with a given load applied from above. The supporting frame and the rear plate was hermetically sealed by the same method to complete the image display device.

[0050] Since the sheet frit was integrated by fusion in advance, the sheet frit is hardly collapsed by hermetic sealing by baking to facilitate the sealing work.

[0051] <Example 6> An electron source of the surface conduction electron emission (SCE) type was used as the electron source disposed on the rear plate 3 in Example 3. Fig. 6 is a plane view showing the rear plate 3 in this example.

[0052] Many wiring lines 7 in a vertical direction and wiring lines 9 in a horizontal direction in the drawing were formed on an insulation substrate 1 made of a glass on the

rear plate 3, and a plurality of electron emission elements 10 on which a voltage is impressed by the vertical direction wiring lines 7 and horizontal direction wiring lines 9 were disposed near the crossing points between the vertical direction wiring lines 7 and horizontal direction wiring lines 9. Both wiring lines of the vertical direction wiring lines 7 and horizontal direction wiring lines 9 are insulated with each other at each crossing point with an interlayer insulation film 8. The electron emission element 10 used is the surface conduction electron emission element as described above. The vertical direction wiring lines 7, interlayer insulation film 8, horizontal direction wiring lines 9 and the electron emission element 10 are formed by a photolithographic etching method according to the process for manufacturing a semiconductor device.

[0053] No leak was observed when the inside of the image display device after the hermetic sealing step in this example was evacuated to vacuum through the evacuation pipe. This means that a large screen image display device using the SCE electron source may be manufactured with no possibility of leak by using the hermetic sealing step by continuously disposing the sheet frits having the engaging parts.

[0054] <Example 7> The vacuum vessel may be hermetically sealed with no possibility of leak by disposing many tablets

of the sheet frit on the sealing part in duplicate by displacing the ends of the tablets with each other. The method for manufacturing the image display device as in Example 2 will be described in this example. Fig. 7(a) is a partially broken plane view showing the image display device in Example 7, and Fig. 7(b) is provided for describing the hermetic sealing step.

[0055] The tablets of the sheet frits 30 are disposed in dual layers and baked at each sealing part 6 between the supporting frame 5 and rear plate 3, and between the supporting frame 5 and face plate 4 to hermetically seal them. The sheet frit 30 (the sheet frit in the first layer) directly laminated on the supporting frame 5, and the second layer sheet frit laminated on the first layer sheet frit 30 are distinguished by changing the direction of hatching as shown in the drawing. The frits on the first layer are continuously disposed on the supporting frame 5 with slight gaps left behind so that the longitudinal direction of the sheet frit is in the edge direction of the supporting frame 5. While the sheet frits on the second layer are disposed likewise, the ends of the second sheet frits in the longitudinal direction are disposed so as to be disposed at near the center of the sheet frits on the first layer in the longitudinal direction. In other words, the phase of the disposition of the sheet frits on each layer is different

just a half period between the first and second layers. An evacuation pipes 21 for evacuating the inside of the vessel composed of the supporting frame 5, rear plate 3 and face plate 4 is provided in the supporting frame 5.

[0056] A practical example for manufacturing the image display device in this example will be described below. Suppose that the rear plate 3 and face plate 4 are constructed using a rectangular blue sheet glass (soda glass) with an width of 320 mm and a length of 240 mm. Many cathodes are formed on the rear plate 3 by a vacuum deposition method and photolithographic technique. The sheet frits 30 previously calcinated in tablets was disposed on the sealing part of the rear plate 3 so as to be continuous with each other. The sheet frit 30 is a composite low melting point glass prepared by blending a $PbO \cdot B_2O_3$ low melting point glass commercially available as a display panel sealing glass and a special ceramic powder, and is used as a glass frit with a sealing temperature of 410°C. The glass frit is extended into a sheet by adding a vehicle (prepared by dissolving a low polymerization degree acrylic resin in α-terpineol in 5% concentration), followed by cutting into tablets. The tablets are calcinated at 360 to 380°C to decompose and sublimate the vehicle, thereby obtaining the tablets of the sheet frits 30 with a length of 80 mm, an width of 4 mm and a thickness of 0.4 mm.

[0057] For continuously aligning the sheet frits 30 on the sealing part, or for arranging the sheet frit so that the gaps at near the ends of the sheet frit 30 in the longitudinal direction becomes as small as possible, the sheet frits were aligned by cutting them with a pair of tweezers when the length of the sheet frit 30 is too large. After aligning the sheet frits 30 of the first layer on the circumference of the sealing part, the sheet frits were arranged on the second layer so that the ends of the sheet frits on the second layer are displaced from the ends of the sheet frits on the first layer.

[0058] Subsequently, the supporting frame 5 provided with an evacuation tube 21 was disposed o as to be overlapped on the sheet frit 30. Then, tow layers of the sheet frits 30 were overlapped on the sealing part between the sheet frit and face plate 4 on the supporting frame 5, as in the case of the sealing part of the rear plate 3. The face plate 4 was placed so that the fluorescent face is opposed to the rear plate 3. Finally, the assembly was heated at near 410°C that is a sealing temperature of the sheet frit 30 for several tens minutes while compressing it by loading an weight, followed by cooling to complete the hermetic sealing step. The hermetic sealing of the enclosure of the image display device manufactured as described above was evaluated using a helium detector, and no leak was confirmed at a

maximum sensitivity of the leak detector (1×10^{-10} atm·cm^3/sec or less).

[0059] After manufacturing the enclosure capable of hermetic sealing, the inside of the image display device was evacuated into vacuum of 1×10^{-7} Torr through the evacuation pipe 21, followed by sealing the evacuation pipe 21. A getter (not shown) was allowed to operate for maintaining the degree of vacuum to complete the image display device. The image display device manufactured as described above showed no leak at the sealing part to enable good images to be displayed.

[0060] <Example 8> While two layers of the sheet frits 30 were disposed on the sealing part in Example 7, two lines of the sheet frits were aligned in Example 8. Fig. 8(a) is a partially broken plane view showing the image display device of this example, while Fig. 8(b) illustrates the hermetic sealing step thereof. The sheet frits 30 disposed at the inside on the sealing part and the sheet frits 30 disposed at the outside on the sealing part are distinguished with each other by the directions of hatching.

[0061] A practical method for manufacturing the image display device in this example will be described below. In an example, the rear plate 3, face plate 4 and supporting frame 5 were the same as those used in Example 7, and the composition, production method and the size of the sheet

frit 30 were also the same as used in Example 7.

[0062] The sheet frits 30 described above were continuously aligned on the sealing part at the circumference of the rear plate 3. The length of the sheet frit was adjusted with a pair of tweezers when the length of the sheet frit is too large for aligning on the sealing part. After aligning the sheet frits 30 on the circumference, the other sheet frits 30 were also aligned at the outside of the sheet frits above. The ends of the sheet frits 30 at the inside, and ends of the sheet frits 30 at the outside were disposed so that they do not meet together, or so that the ends are alternately aligned.

[0063] Subsequently, the supporting frame 5 provided with the evacuation tube 21 was placed so as to overlap on the sheet frits 30. The sheet frits 30 were aligned in tow lines at the inside and outside on the sealing part between the supporting frame 5 and face plate 4, as in the case of the sealing part of the rear plate 3. The face plate 4 was disposed so that the fluorescent face is opposed to the rear plate 3. Finally, the assembly was heated at near 410°C that is a sealing temperature of the sheet frit 30 for several tens minutes while compressing it by loading an weight, followed by cooling to complete the hermetic sealing step. The hermetic sealing of the enclosure of the image display device manufactured as described above was evaluated

using a helium detector, and no leak was confirmed at a maximum sensitivity of the leak detector (1×10^{-10} atm·cm^3/sec or less).

[0064] After manufacturing the enclosure capable of hermetic sealing, the inside of the image display device was evacuated into vacuum of 1×10^{-7} Torr through the evacuation pipe 21, followed by sealing the evacuation pipe 21. A getter (not shown) was allowed to operate for maintaining the degree of vacuum to complete the image display device. The image display device manufactured as described above showed no leak at the sealing part to enable good images to be displayed.

[0065] <Example 9> The surface conduction electron emission (SCE) electron source used in Example 7 was used as the cathode disposed on the rear plate 3. The rear plate 3 is the same as described in Example 6 using Fig. 6.

[0066] The rear plate 3, supporting frame 5 and face plate 4 were hermetically sealed by the same method as in Example 7. Hermetic sealing of the enclosure of the image display device manufactured as described above was evaluated with a helium detector, and no leak was confirmed at a maximum sensitivity of the leak detector (1×10^{-10} atm·cm^3/sec or less).

[0067] After manufacturing the enclosure capable of hermetic sealing, the inside of the image display device was

evacuated into vacuum of 1×10^{-7} Torr through the evacuation pipe 21, followed by sealing the evacuation pipe 21. A getter (not shown) was allowed to operate for maintaining the degree of vacuum to complete the image display device. The image display device manufactured as described above showed no leak at the sealing part to enable good images to be displayed.

[0068] <Example 10> The surface conduction electron emission (SCE) electron source used in Example 8 was used as the cathode disposed on the rear plate 3. The rear plate 3 is the same as described in Example 6 using Fig. 6.

[0069] The rear plate 3, supporting frame 5 and face plate 4 were hermetically sealed by the same method as in Example 7. Hermetic sealing of the enclosure of the image display device manufactured as described above was evaluated with a helium detector, and no leak was confirmed at a maximum sensitivity of the leak detector (1×10^{-10} atm·cm^3/sec or less).

[0070] After manufacturing the enclosure capable of hermetic sealing, the inside of the image display device was evacuated into vacuum of 1×10^{-7} Torr through the evacuation pipe 21, followed by sealing the evacuation pipe 21. A getter (not shown) was allowed to operate for maintaining the degree of vacuum to complete the image display device. The image display device manufactured as described above

showed no leak at the sealing part to enable good images to be displayed.

[0071]

[Advantages] As described above, the sheet frit of the invention, or the sheet frit having the engaging part, is used by engaging the engaging parts with each other, and the sheet frit is not required to be calcinated together with the enclosure having the sealing part on which the sheet frit is disposed. Accordingly, the invention can exert the following effects: (1) the heat cycles applied to the enclosure is substantially only one time for hermetic sealing to save the labor of manufacturing the enclosure; (2) no baking furnace for calcinating the enclosure having a large volume is needed, and the installation space for the baking furnace can be eliminated; (3) hermetic sealing of a large size flat image display device is enabled without restricted by the size of the sealing part; and (4) risks of accidental breaking by handling is substantially reduced since a limited length of sheet frit is used in combination. The efficiency of the hermetic sealing work of the large size flat image display device is largely improved. Accordingly, the sheet frit of the invention is particularly suitable for use in hermetic sealing of the image display device while enabling a large screen image display device to be manufactured.

[0072] The method for hermetically sealing the second and third vacuum vessels of the invention, and the method for manufacturing the third and fourth image display device of the invention use a plurality of sheet frits that are formed into pieces of small sheets not always provided with the engaging parts. The sheet frits are arranged in duplicate or more at the sealing part, and are not required to be calcinated together with the enclosure having the sealing part on which the sheet frits are disposed. Accordingly, the invention can exert the following effects: (1) the heat cycles applied to the enclosure is substantially only one time for hermetic sealing to save the labor of manufacturing the enclosure; (2) no baking furnace for calcinating the enclosure having a large volume is needed, and the installation space for the baking furnace can be eliminated; and (3) hermetic sealing of a large size flat image display device is enabled without restricted by the size of the sealing part. Accordingly, the sheet frit of the invention is particularly suitable for use in hermetic sealing of the image display device while enabling a large screen image display device to be manufactured.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1(a) to 1(f) are perspective views, respectively, showing the sheet frit of the invention.

[Fig. 2] Fig. 2 is a perspective view for illustrating the

image display device in Example 2.

[Fig. 3] Fig. 3 is a perspective view for illustrating the hermetic sealing step of the image display device in Example 2.

[Fig. 4] Fig. 4(a) is a partially broken plane view of the image display device in Example 3, and Fig. 4(b) is a front view for illustrating the hermetic sealing step of the image display device in Example 3.

[Fig. 5] Fig. 5 is a perspective view for illustrating the hermetic sealing step of the image display device in Example 4.

[Fig. 6] Fig. 6 is a plane view of the rear plate provided with SCE electron emission elements.

[Fig. 7] Fig. 7(a) is a partially broken plane view of the image display device in Example 7, and Fig. 7(b) is a front view for illustrating the hermetic sealing step in Example 7.

[Fig. 8] Fig. 8(a) is a partially broken plane view of the image display device in Example 8, and Fig. 8(b) is a front view for illustrating the hermetic sealing step in Example 8.

[Reference Numerals]

3 rear plate

4 face plate

5 supporting frame

6 sealing part

7 horizontal wiring line (in the drawing)

8 interlayer insulation layer

9 vertical wiring line (in the drawing)

10 electron emission element

20 laser beam

21 evacuation tube

30, 101, 102, 103, 104, 105, 106 sheet frit

101a, 104a step

102a groove

105a, 106a inclined face

Fig. 1

101, 102, 103, 104, 105, 106 sheet frit

101a, 104a, step

102a groove

105a, 106a inclined face

Fig. 2

3 rear plate

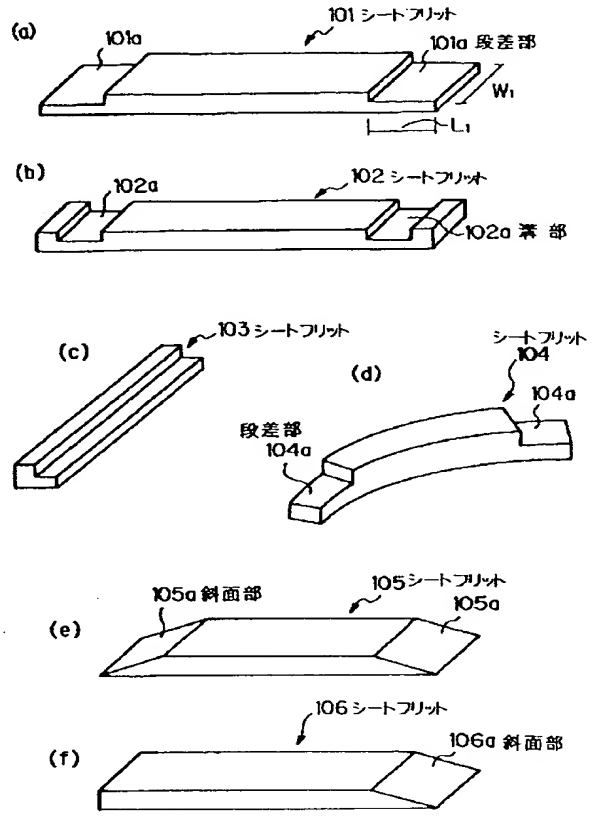
4 face plate

6 sealing part

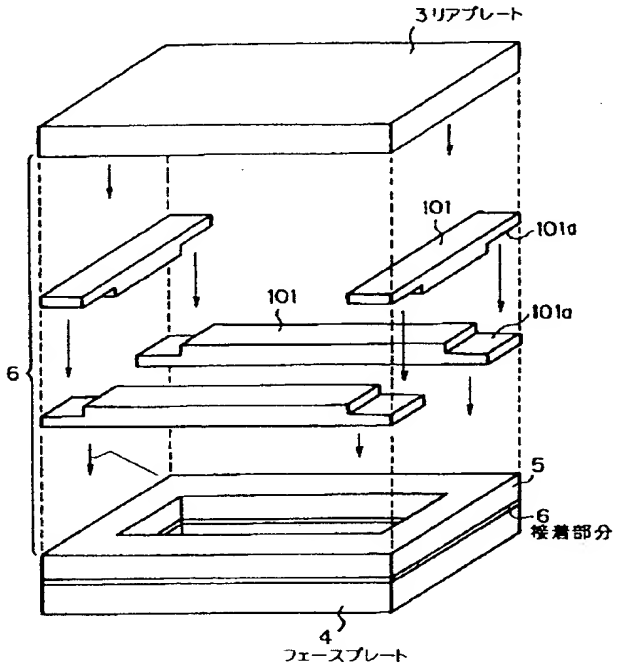
Fig. 5

20 laser beam

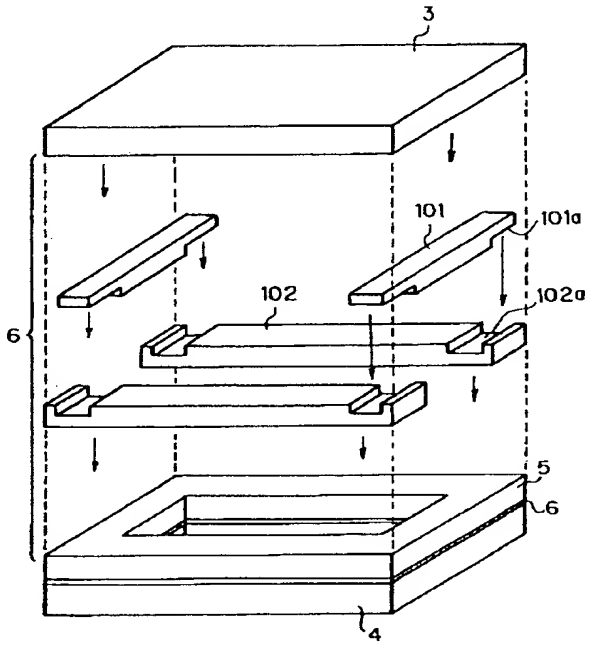
【図1】 FIG. 1



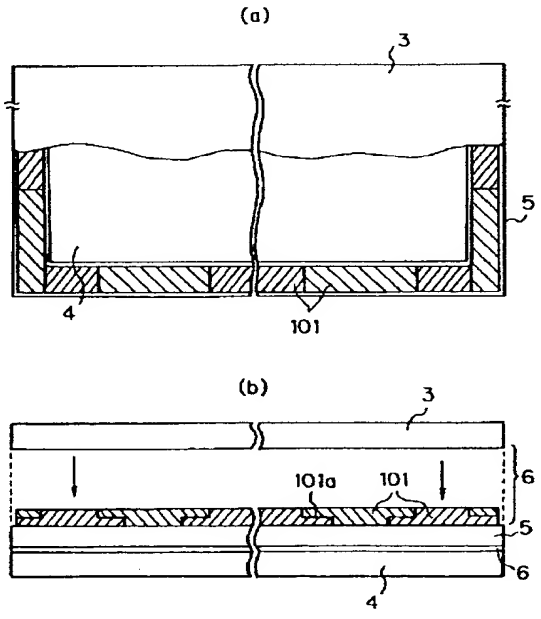
【図2】 FIG. 2



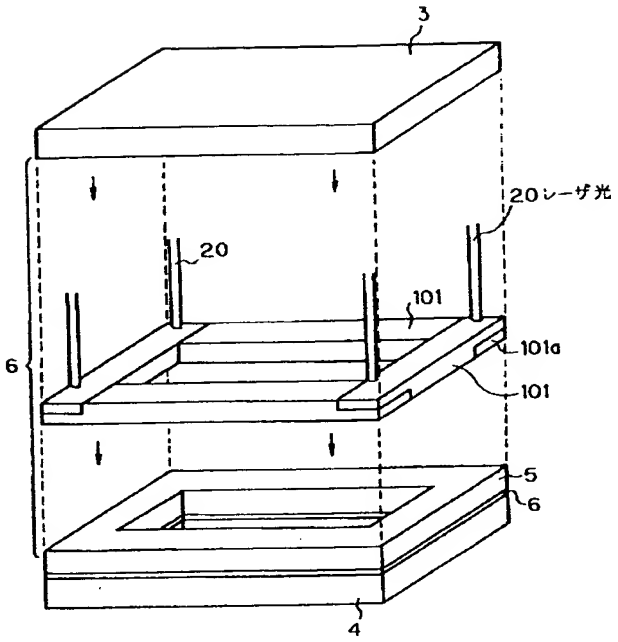
【図3】 FIG. 3



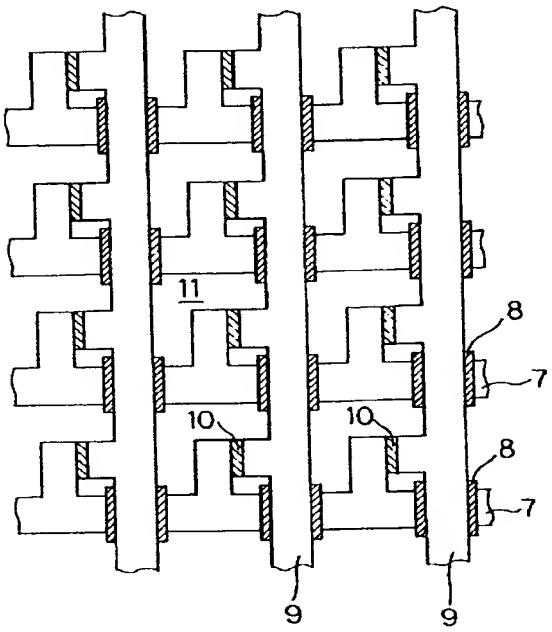
【図4】 FIG. 4



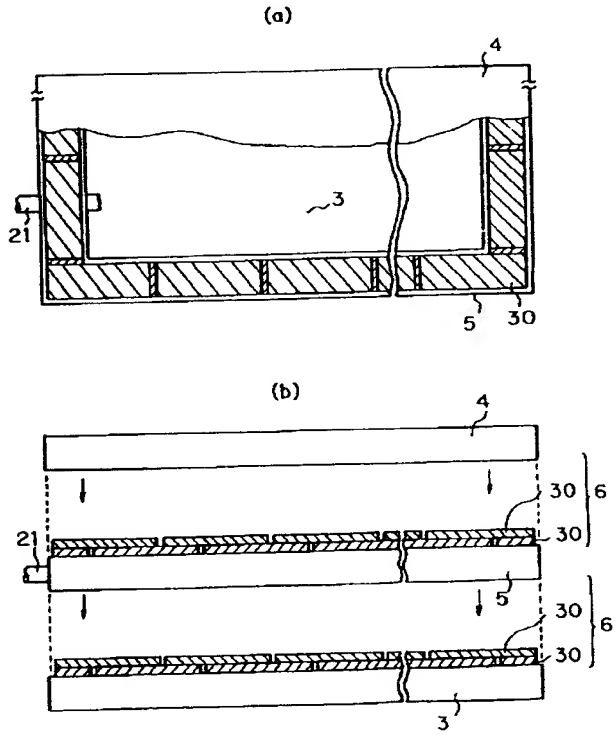
【図5】 FIG.5



【図6】 FIG.6



【図7】 FIG.7



【図8】 FIG.8